Attorney Docket No. 02075/TL

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant(s): Alois BIEBL

Serial No. : To be assigned

Filed : Concurrently herewith

For : DRIVE CIRCUIT FOR AN LED ARRAY

Art Unit :

Examiner :

Express Mail Mailing Label No.: EV 044 466 082 US
Date of Deposit: February 12, 2002

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PRELIMINARY AMENDMENT

Asst. Commissioner for Patents
Washington, D.C. 20231

S I R :

Please amend the above-identified application as follows (with changes being shown on the attachments hereto):

IN THE SPECIFICATION

Page 1, replace the heading "Technical Field" with --Field of the Invention--;

replace the heading "Prior Art" with --Background of the Invention--.

Page 4, replace paragraph 3, corresponding to page 4, line 35 to page 5, line 2 as follows:

One object of the present invention is to provide a drive circuit for an LED array that ensures continuing operation of the LED array with a cost-effective implementation if the entire luminance of the LED array lies above a prescribable value.

Page 5, replace paragraph 1, corresponding to page 5, lines 4-7 as follows:

This and other objects are attained by a drive circuit having the features of patent claim 1, and by a method for operating an LED array having the features of patent claim 17.

Page 5, replace paragraph 2, corresponding to page 5, lines 9-32 as follows:

The point of departure is a patent application of the present applicant entitled "Ansteuerschaltung für LED und zugehöriges Betriebsverfahren" ["Drive circuit for LEDs and associated method of operation"] (application No. DE19950135.1; Biebl), in the case of which a plurality of LED clusters are operated in a cascade arrangement. In this case, a higher-level LED cluster is denoted as master cluster, and its average current is fed to a control loop, the drive signal of the master cluster also being used to drive a plurality of lower-level LED clusters, what are termed slave clusters. Starting from the teaching of the application just mentioned, the above object of the invention can be achieved when the total current through all the slave clusters is measured and this current is compared against a prescribable desired value. No fault message is generated as long as the total current lies above the threshold value despite failure of individual slave clusters. A fault signal is not generated until the prescribed threshold value is undershot, which is the same as saying, for example, that the diminished luminance now no longer corresponds to the statutory stipulations.

Page 10, replace the heading "Description of the drawings" with --Brief Description of the Drawings--.

Page 11, after line 1 insert the heading --Detailed Description of the Drawings--.

IN THE ABSTRACT

Replace the Abstract with the following:

Abstract of the Disclosure

A drive circuit for an LED array which comprises a first LED cluster (40) and at least one second LED cluster (42; 44), the switch (S1, S2, S3) being arranged in series with each LED cluster (40, 42, 44), and each LED cluster (40, 42, 44) having a supply terminal. A control loop (46) is designed to drive the switch (S1) of the first LED cluster (42) so as to achieve a constant mean value of the current (I_{LED}) flowing through the first LED cluster (42), the control loop (46) being designed for also driving the switches of the further LED clusters (42, 44). The drive circuit also comprises a total current detection device (R_{Mess}) with the aid of which it is possible to determine an actual magnitude (U_{Mess}) which corresponds to the sum of the currents through at least two, in particular through all of the second LED clusters (42, 44). A comparison unit (50) compares the actual magnitude (U_{Mess}) with a predefinable desired magnitude (U_{OL}).

IN THE CLAIMS

Amend claims 3, 4, 7, 9, 10 and 12-15, as follows.

3. (Amended) The drive circuit as claimed in claim 1, characterized in that the comparison unit (50, 50a) is designed to output an information signal (78) in the event of

undershooting of the desired magnitude (U_{OL}) by the actual magnitude (U_{Mess}).

4. (Amended) The drive circuit as claimed in claim 1, characterized in that it comprises a monitoring unit (50, 50b), with which the current flow through the first LED cluster (40) can be monitored.

7. (Amended) The drive circuit as claimed in claim 1, characterized in that it also comprises an undervoltage detection device (64) which is designed to output an undervoltage warning signal (76) when the supply voltage (U_{Batt}) falls below a prescribable value (U_{Ref1}).

9. (Amended) The drive circuit as claimed in claim 7, characterized in that the prescribable value (U_{Ref1}) can be set manually or can be prescribed permanently.

10. (Amended) The drive circuit as claimed in claim 3, characterized in that it also comprises an output unit (50, 50c, ST1) to which the information signal (78) and/or the undervoltage warning signal (76) can be transmitted.

12. (Amended) The drive circuit as claimed in claim 1, characterized in that it also comprises a closing delay device (74) which is designed to deactivate the output unit (50, 50c, ST1) for a predetermined time after the closure of the drive circuit.

13. (Amended) The drive circuit as claimed in claim 10, characterized in that the output unit (50, 50c, ST1) comprises a flip-flop (88), the base of the transistor (ST1) being connected to the output of the flip-flop (88), and the set input (S) of the flip-flop (88) being connected to the undervoltage detection device (64) in order to transmit the undervoltage warning signal

(76), and/or being connected to the comparison unit (50a) in order to transmit the information signal (78).

14. (Amended) The drive circuit as claimed in claim 12, characterized in that the closing delay device (74) is designed to apply a closing delay signal (80) to the reset input (R) of the flip-flop (88) of the output unit (50, 50c, ST1) over the duration of the closing delay.

15. (Amended) The drive circuit as claimed in claim 1, characterized in that the actual magnitude (U_{Mess}) corresponds to a time average value of the sum of the currents through at least two, in particular through all of the second LED clusters (42, 44).

Respectfully submitted,

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ATTACHMENT

3. (Amended) The drive circuit as claimed in claim 1 [or 2], characterized in that the comparison unit (50, 50a) is designed to output an information signal (78) in the event of undershooting of the desired magnitude (U_{OL}) by the actual magnitude (U_{Mess}).

4. (Amended) The drive circuit as claimed in [one of the preceding claims] claim 1, characterized in that it comprises a monitoring unit (50, 50b), with which the current flow through the first LED cluster (40) can be monitored.

7. (Amended) The drive circuit as claimed in [one of the preceding claims] claim 1, characterized in that it also comprises an undervoltage detection device (64) which is designed to output an undervoltage warning signal (76) when the supply voltage (U_{Batt}) falls below a prescribable value (U_{Ref1}).

9. (Amended) The drive circuit as claimed in [one of claims 7 or 8] claim 7, characterized in that the prescribable value (U_{Ref1}) can be set manually or can be prescribed permanently.

10. (Amended) The drive circuit as claimed in [one of claims 3 to 9] claim 3, characterized in that it also comprises

an output unit (50, 50c, ST1) to which the information signal (78) and/or the undervoltage warning signal (76) can be transmitted.

12. (Amended) The drive circuit as claimed in [one of the preceding claims] <u>claim 1</u>, characterized in that it also comprises a closing delay device (74) which is designed to deactivate the output unit (50, 50c, ST1) for a predetermined time after the closure of the drive circuit.

13. (Amended) The drive circuit as claimed in [one of claims 10 to 12] <u>claim 10</u>, characterized in that the output unit (50, 50c, ST1) comprises a flip-flop (88), the base of the transistor (ST1) being connected to the output of the flip-flop (88), and the set input (S) of the flip-flop (88) being connected to the undervoltage detection device (64) in order to transmit the undervoltage warning signal (76), and/or being connected to the comparison unit (50a) in order to transmit the information signal (78).

14. (Amended) The drive circuit as claimed in [one of claims 12 or 13] <u>claim 12</u>, characterized in that the closing delay device (74) is designed to apply a closing delay signal (80) to the reset input (R) of the flip-flop (88) of the output unit (50, 50c, ST1) over the duration of the closing delay.

15. (Amended) The drive circuit as claimed in [one of the preceding claims] claim 1, characterized in that the actual magnitude (U_{Mess}) corresponds to a time average value of the sum of the currents through at least two, in particular through all of the second LED clusters (42, 44).

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Drive circuit for an LED array

~~Technical field~~

Field of the Invention

The present invention relates to a drive circuit for an LED array which comprises a first LED cluster and at least one second LED cluster, a switch being arranged in series with each LED cluster, and each LED cluster having a supply terminal via which it can be connected to a supply voltage, it being possible to drive each switch so as to permit a current flow in the associated LED cluster, having a control loop which is designed to drive the switch of the first LED cluster so as to achieve a constant mean value of the current flowing through the first LED cluster, the control loop being designed to drive at least one switch of a second LED cluster. It relates, moreover, to a method for operating an LED array which comprises a first LED cluster and at least one second LED cluster, a switch being arranged in series with each LED cluster, and each LED cluster having a supply terminal via which it can be connected to a supply voltage.

~~Prior art~~

Background of the Invention

The invention is concerned with driving LEDs. It is normal for this purpose to use series resistors or current sources which limit and/or control the current through the LED. The LEDs are generally interconnected to form a cluster, that is to say a cluster comprises a series circuit of a plurality of LEDs. A plurality of LED clusters must be connected in parallel, that is to say be combined to form an array, depending on the size of the area to be lit or backlit. There is the basic problem here that a status terminal of the drive circuit is intended to supply a corresponding

dashes, for further blocks to be part of the same LED array.

The problem with this solution is, firstly, the additional outlay for a counter 28 and a multiplexer 30 and, on the other hand, the fact that a plurality of LED driver blocks are required in the case of larger LED arrays, since the number of current control loops per LED driver block is limited, for example to eight. The use of a plurality of LED driver blocks is reflected, in turn, disadvantageously in the price.

In addition to the disadvantages mentioned, in the case of the solutions addressed there is a further disadvantage that a fault signal is output immediately as soon as a fault has occurred. This is necessary, however, only if, as in the case of the first named solution, the complete LED cluster has failed. With regard to specific fields of application of LED arrays, for example in the vehicle sector as taillights, this would again justify the use of an incandescent bulb. In the case of an incandescent bulb, there also exists only two states of incandescent bulb intact and incandescent bulb not intact. The advantage of using LEDs in this sector resides, however, in the fact that in the event of failure of an LED cluster the light is capable of continuing to be operated if sufficient other functioning LED clusters are still present - although with somewhat diminished luminance - but, if suitably dimensioned, still above a limiting value prescribed by statute.

Summary of the invention

~~The~~ one object of the present invention is to provide a ~~therefore consists in developing the~~ drive circuit ~~named at the beginning~~ for an LED array ~~in such a way that the further~~ that ensures continuing operation of the LED array ~~is ensured in conjunction~~ with a cost-effective implementation ~~realization~~ if the entire

luminance of the LED array lies above a prescribable value.

and other objects are attained

This problem is solved by a drive circuit having the features of patent claim 1, and by a method for operating an LED array having the features of patent claim 17.

The point of departure is a patent application of the present applicant entitled "Ansteuerschaltung für LED und zugehöriges Betriebsverfahren" ["Drive circuit for LEDs and associated method of operation"] (application No. DE19950135.1; Biebl; not yet laid open), in the case of which a plurality of LED clusters are operated in a cascade arrangement. In this case, a higher-level LED cluster is denoted as master cluster, and its average current is fed to a control loop, the drive signal of the master cluster also being used to drive a plurality of lower-level LED clusters, what are termed slave clusters. Starting from the teaching of the application just mentioned, the finding of the invention consists in that the above object of the invention can be achieved when the total current through all the slave clusters is measured and this current is compared against a prescribable desired value. No fault message is generated as long as the total current lies above the threshold value despite failure of individual slave clusters. A fault signal is not generated until the prescribed threshold value is undershot, which is the same as saying, for example, that the diminished luminance now no longer corresponds to the statutory stipulations.

This realization offers the advantage that the entire LED array can be operated despite failure of individual LED clusters, that the fault detection logic circuit can be kept very simple, in particular need be provided only once, and, finally, that the LED array with an arbitrary number of LED clusters can be monitored by

clusters is measured as actual magnitude, the actual magnitude subsequently being compared with a prescribable desired magnitude.

Brief Description of the drawings

Further advantageous embodiments are defined in the subclaims. Exemplary embodiments of the invention are described below in more detail with reference to the attached drawings, in which:

figure 1 illustrates a circuit arrangement, known from the prior art, for driving an LED cluster with pulsed current control;

figure 2 illustrates a drive circuit, known from the prior art, for a plurality of LED clusters with a multiplexer;

figure 3 illustrates a first exemplary embodiment of a drive circuit according to the invention with detection of the total current of the slave clusters;

figure 4a illustrates the characteristic of the fault signal in the event of occurrence of a fault of decisive importance;

figure 4b illustrates the time characteristic of the voltage U_{Mess} in the event of failure of individual LED clusters in the exemplary embodiment of figure 3;

figure 5 shows a detailed illustration of the embodiment of figure 3; and

figure 6 shows a schematic illustration of a block diagram of an embodiment of the fault diagnosis for a drive circuit according to

the invention.

Detailed Description of the Drawings

Identical reference symbols are used throughout below for identical and equivalent elements of the various exemplary embodiments.

In the drive circuit illustrated in figure 3, a first LED cluster 40 with two LEDs D1, D2 is denoted as master cluster. A plurality of second LED clusters 42, 44 with LEDs D3, D4, D5, D6 are denoted as slave clusters. Of course, a multiplicity of LEDs can be arranged per cluster instead of the two LEDs shown by way of example. This is limited essentially by whether the battery voltage U_{Batt} used for the supply suffices in order to apply the sum of the LED forward voltages.

The current flow through the master cluster 40 is detected by means of a resistor R_{Shunt}, the voltage U_{Shunt} dropping across the resistor R_{Shunt} being fed to an LED drive circuit 46. The latter supplies the drive clock pulse CLK for the switch S1 of the master cluster 40, as well as for the switches S2, S3 of the slave clusters 42 and 44. The total current through the slave clusters is determined via a resistor R_{Mess}, the voltage U_{Mess} dropping across the resistor R_{Mess} being fed to the diagnosis unit 50. The latter continues to receive the battery voltage U_{Batt} as well as a signal 48 fed by the LED drive unit 46. The diagnosis unit 50 for its part supplies a signal 58 to the LED drive unit 46. The signals 48 and 58 are described further below in yet more detail, as is the design of the diagnosis unit 50. The output signal of the diagnosis unit 50 is applied to the base of a status transistor ST1 in an open collector circuit. An item of information on the status of the LED array is provided at a collector of the transistor ST1.

Figure 4b shows the time characteristic of the voltage U_{Mess} dropping across the resistor R_{Mess}. Also plotted is

Abstract of the Disclosure

~~a~~ A drive circuit

The present invention relates to ~~a~~ A drive circuit for an LED array which comprises a first LED cluster (40) and at least one second LED cluster (42; 44), the switch (S1, S2, S3) being arranged in series with each LED cluster (40, 42, 44), and each LED cluster (40, 42, 44) having a supply terminal. A control loop (46) is designed to drive the switch (S1) of the first LED cluster (42) so as to achieve a constant mean value of the current (I_{LED}) flowing through the first LED cluster (42), the control loop (46) being designed for also driving the switches of the further LED clusters (42, 44). The drive circuit also comprises a total current detection device (R_{Mess}) with the aid of which it is possible to determine an actual magnitude (U_{Mess}) which corresponds to the sum of the currents through at least two, in particular through all of the second LED clusters (42, 44). A comparison unit (50) compares the actual magnitude (U_{Mess}) with a predefinable desired magnitude (U_{OL}).

(Figure 3)